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(54) ITH MOLECULAR SIEVE IMPROVED LOUDSPEAKER, AND ELECTRONIC DEVICE

(57) The present disclosure discloses a loudspeaker improved by an ITH molecular sieve, and an electronic device. A rear cavity of the speaker is filled with the ITH molecular sieve. The ITH molecular sieve includes a framework and extra-framework cations. The framework contains silicon dioxide and an oxide of a non-silicon element M. A Si/M molar ratio is at least 80 or more,

and exemplarily 100 or more. The ITH molecular sieve has uniform micropores with a micropore size of 0.4 Å to 0.55 Å and a micropore volume of 0.10 cm³/g to 0.25 cm³/g. The inclusion of the ITH molecular sieve in the rear cavity of the loudspeaker increases acoustic compliance of air in the rear chamber, and thereby improving performance of the speaker in a low-frequency band.

NITROGEN ADSORPTION AT ROOM TEMPERATURE

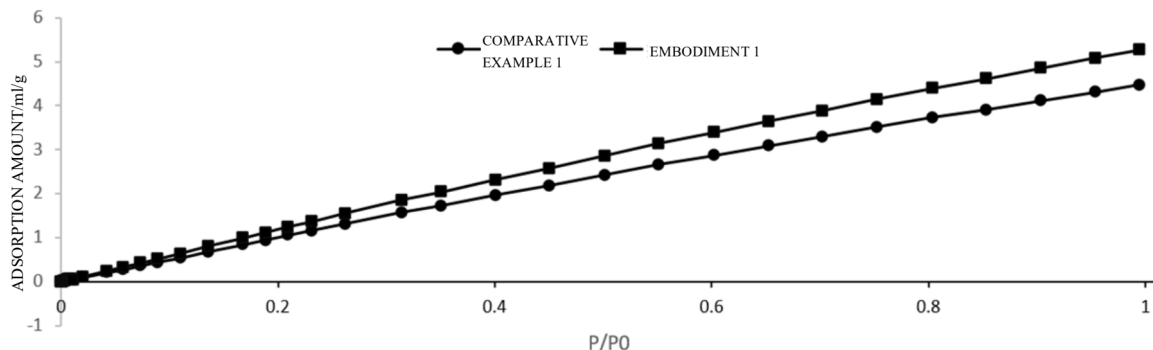


FIG. 1

Description

[0001] The present application claims priority to a Chinese Patent Application No. 202310250461.3 filed with the China National Intellectual Property Administration on March 15, 2023 and entitled "LOUDSPEAKER IMPROVED BY ITH MOLECULAR SIEVE, AND ELECTRONIC DEVICE", which is incorporated in the present application by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure belongs to the field of loudspeaker devices, and particularly relates to a loudspeaker improved by an ITH molecular sieve, and an electronic device.

BACKGROUND ART

[0003] With development of science and technology, people have increasingly high requirements for loudspeakers, especially mobile phone loudspeaker, which requirements are not only a small size and sound production, but also good sound quality while being small in size. The quality of sound is related to every aspect of design and manufacturing process of the loudspeaker, especially a designed size of a rear cavity of the loudspeaker. Under normal circumstances, a reduction in size of the rear cavity of the loudspeaker may significantly decrease a response in a low-frequency band, resulting in poor sound quality, and therefore, it is difficult to provide good sound quality under a condition of a very small rear cavity.

[0004] To solve the above problem, engineers have proposed various methods, such as 1) using a gas having higher acoustic compliance to replace air as an atmosphere in rear cavity, 2) filling the rear cavity with foams such as melamine to increase the acoustic compliance, and 3) filling the rear cavity with porous materials such as activated carbon, zeolite, and silicon dioxide to increase a virtual rear cavity volume and improve the acoustic compliance. Among these, the third method has the most obvious effect.

[0005] CN101416528A proposes to use shaped activated carbon as a loudspeaker improvement material. CN103477655A uses a porous carbon material as a loudspeaker low-frequency improvement material, and uses Cu-ZSM-5 to adsorb water vapor to prevent a water vapor pressure in a rear cavity from being too high and clogging the porous carbon. A loudspeaker improvement material proposed in CN105013436A mainly contains FER, MFI and BEA as a zeolite structure.

[0006] An ITH molecular sieve is generally called ITQ-13, and is a novel microporous material with a three-dimensional orthogonally intersecting channel structure composed of both 9-membered rings and 10-membered rings, in which the 9-membered ring channels are parallel to an a-axis and are straight channels with an opening size of $0.40\text{ nm} \times 0.49\text{ nm}$, and another two sets of 10-membered ring channels are respectively straight channels ($0.47\text{ nm} \times 0.51\text{ nm}$) parallel to a b-axis and sinusoidal tortuous channels ($0.48\text{ nm} \times 0.57\text{ nm}$) roughly parallel to a c-axis.

SUMMARY

[0007] The present disclosure provides a loudspeaker improved by an ITH molecular sieve, and an electronic device. A rear cavity of the loudspeaker is filled with an ITH molecular sieve material. The addition of the material can significantly improve low-frequency performance of the loudspeaker.

[0008] To achieve the above objective, the present disclosure adopts the following technical solutions.

[0009] One aspect of the present disclosure provides a loudspeaker improved by an ITH molecular sieve, in which a rear cavity of the loudspeaker is filled with the ITH molecular sieve, and

The ITH molecular sieve comprises a framework and extra-framework cations. The framework contains silicon dioxide and an oxide of a non-silicon element M, and a Si/M molar ratio is at least 80 or more, and preferably 100 or more.

[0010] The ITH molecular sieve has uniform micropores with a micropore size of 0.4 Å to 0.55 Å and a micropore volume of $0.10\text{ cm}^3/\text{g}$ to $0.25\text{ cm}^3/\text{g}$.

[0011] If the micropore size of the ITH molecular sieve is less than 0.4 Å , since the size of nitrogen molecules is 0.364 Å , the channel size is very close to the nitrogen size, and thus rapid adsorption, desorption and diffusion of nitrogen in the channel are limited. If the micropore size is too large, a physical force corresponding to the nitrogen molecules is reduced, and enrichment and analysis amounts of nitrogen in the channel corresponding to the change of sound pressure is limited, resulting in an undesirable effect. If the micropore volume is too small, the corresponding ITH crystallinity is insufficient. If there are not enough micropores, the corresponding acoustic performance is very limited. Exemplarily, the micropore volume is $0.15\text{ cm}^3/\text{g}$ to $0.25\text{ cm}^3/\text{g}$.

[0012] According to the loudspeaker of the present disclosure, exemplarily, the non-silicon element M is a trivalent, tetravalent or pentavalent ion. Here, the trivalent ion mainly includes but is not limited to Al, Fe, B, and the like, the tetravalent ion mainly includes but is not limited to Ge, Ti, Zr, and the like, and the pentavalent ion mainly includes but is not

limited to Ga and the like. More exemplarily, the non-silicon element M is B or Al.

[0013] According to the loudspeaker of the present disclosure, exemplarily, the extra-framework cations are selected from at least one selected from the group consisting of H ions, alkali metal ions or alkaline earth metal ions, and more exemplarily, the extra-framework cations are selected from at least one selected from the group consisting of alkali metals or alkaline earth metals.

[0014] Normally, the framework of the ITH molecular sieve mainly contains silicon dioxide and germanium dioxide. Germanium-containing molecular sieves may undergo hydrolysis upon exposure to humid air, and have poor stability, and usually, scientific research significance thereof is far greater than a practical value thereof. In addition to silicon and germanium, boron is usually introduced into ITH to synthesize boron-containing ITQ-13. There are generally two methods for synthesizing aluminum-containing ITQ-13, which are 1) substitution with boron-containing ITQ-13, and 2) direct synthesis under optimized conditions. In the ITH molecular sieve of the present disclosure, M is exemplarily B or Al. If Si/M is lower than 80, the ITH molecular sieve may significantly absorb moisture in the air and the moisture may occupy most of microporous channels of the molecular sieve, resulting in no low-frequency improvement effect. When synthesizing with other M elements except germanium, if the Si/M ratio is too low, it may cause the synthesis to be difficult or the synthesized ITH structure may deteriorate or be very poor in crystallinity.

[0015] Generally, ITH molecular sieves are exchanged with cations depending on different situation before use to obtain different modified forms of ITH molecular sieves. Ammonium salts, alkali metal salts or alkaline earth metal salts are generally used to exchange with the molecular sieves. Ammonium salts include, but are not limited to ammonium chloride, ammonium nitrate, ammonium sulfate, ammonium carbonate, and the like. Alkali metal salts mainly include lithium salts, sodium salts, potassium salts, rubidium salts, and the like. Anions of alkali metal salts include chloride ions, sulfate ions, nitrate ions, and the like. Alkaline earth metal salts mainly include magnesium salts, calcium salts, barium salts, and the like. Anions of alkali metal salts include chloride ions, sulfate ions, nitrate ions, and the like.

[0016] According to the loudspeaker of the present disclosure, exemplarily, a content of the extra-framework cations is less than 4.5 wt.%, more exemplarily less than 1.5 wt.%, and still more exemplarily 0.05 wt.% to 1.5 wt.%.

[0017] According to the loudspeaker of the present disclosure, exemplarily, a grain size of the ITH molecular sieve is greater than 10 nanometers, and more exemplarily larger than 100 nanometers.

[0018] According to the loudspeaker of the present disclosure, exemplarily, the grain size of the molecular sieve is less than 10 micrometers, and more exemplarily less than 7 micrometers.

[0019] According to the loudspeaker of the present disclosure, exemplarily, in the rear cavity, the ITH molecular sieve is formed into a specific shape by addition of a binder to prevent a raw powder of the molecular sieve from entering a loudspeaker unit. The specific shape is exemplarily a granule-like shape (sphere, ellipsoid, ellipsoid with a pit in the middle, irregular granule, and the like), a sheet-like shape, or a block-like shape. The rear cavity can be filled with the sheet-like or the block-like molecular sieve first, and then assembled, while the rear cavity is generally assembled first and then filled with the granule-like molecular sieve.

[0020] According to the loudspeaker of the present disclosure, exemplarily, a size of formation in granule-like shape is 80 μm to 2000 μm , and more exemplarily 100 μm to 1500 μm .

[0021] According to the loudspeaker of the present disclosure, exemplarily, a size of formation in sheet-like shape is determined according to a cavity body of the rear cavity of the loudspeaker, and exemplarily has a thickness of 100 μm to 1000 μm , and a length and a width of 3 mm to 100 mm.

[0022] According to the loudspeaker of the present disclosure, exemplarily, a size of formation in block-like shape is determined according to the cavity body of the rear cavity of the loudspeaker, and exemplarily has a thickness of 1 mm to 20 mm, and a length and a width of 3 mm to 100 mm.

[0023] Normally, directly synthesized ITH molecular sieves are in a form of powders of 10 μm or less, and mostly need to be formed into a specific shape together with a binder before being placed in the rear cavity of the loudspeaker for use. Direct use of the raw powder without formation may cause the raw powder to enter the loudspeaker unit, affecting the performance of the loudspeaker. During the formation process of the molecular sieve, it is usually necessary to add the molecular sieve to be formed, a solvent, a binder and additives. Among these, the binder can be an inorganic binder or an organic polymer binder. Exemplarily, the inorganic binder includes activated alumina, silica sol, and the like. The organic polymer binder includes acrylates, epoxies, polyurethanes, and the like. The solvent mainly refers to water and various commonly used organic solvents, such as ethanol, toluene, acetone, and tetrahydrofuran. The additive refers to other substances added in very small amounts, usually less than 5%.

[0024] According to the loudspeaker of the present disclosure, the framework of the ITH molecular sieve may not contain the oxide of the non-silicon element M.

[0025] The loudspeaker provided by the present disclosure is filled with the ITH molecular sieve in the rear cavity, which increases the acoustic compliance of air in the rear cavity, thereby improving the performance of the loudspeaker in the low-frequency band.

[0026] Another aspect of the present disclosure provides an electronic device. The electronic device includes any one of the above loudspeakers. The electronic device includes but is not limited to a smart phone, a true wireless stereo (TWS)

headset, a headphone, smart glasses, a smart watch, a VR device, an AR device, a tablet computer or a thin and light laptop.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

FIG. 1 is a comparison diagram of nitrogen adsorption at room temperature of molecular sieve raw powders between Embodiment 1 and Comparative Embodiment 1.

FIG. 2 is a comparison chart of frequency response curves and impedance curves between rear cavities of the loudspeaker with and without an ITH molecular sieve in Embodiment 1.

FIG. 3 is a low-temperature nitrogen adsorption characterization diagram of an aluminum-containing ITH molecular sieve raw powder in Embodiment 3.

DETAILED DESCRIPTION

[0028] In order to explain the present disclosure more clearly, the present disclosure is further described below with reference to embodiments. It should be understood by those skilled in the art that the following specific description is illustrative rather than restrictive, and should not be used to limit the scope of protection of the present disclosure.

[0029] All numerical specifications in the present disclosure (such as temperature, time, concentration, weight, and the like, including ranges of each thereof) are generally approximate values that can be appropriately changed by increments of (+) or (-) 0.1 or 1.0. All numerical specifications can be understood as being preceded by the term "approximately".

Embodiment 1

[0030] In this embodiment, an all-silicon ITH molecular sieve (ITQ-13) was prepared and applied to a loudspeaker to test acoustic performance of the loudspeaker, which includes the following steps.

1) Preparing All-silicon ITH Molecular Sieve (ITQ-13):

[0031] An all-silicon ITH molecular sieve was synthesized by using tetraethyl orthosilicate as a silicon source, hydrogen fluoride as a mineralizer, hexamethonium hydroxide as a template agent, and water, with a specific ratio of 1 SiO_2 :0.5 hexamethonium hydroxide:0.5 HF :7 H_2O . A hydrothermal reaction temperature was 160°C, and a reaction time was 120 h. A crystallized reactant was centrifuged, washed with water, dried at 110°C overnight and calcined at 550°C in air atmosphere for 8 h to obtain an all-silicon ITH raw powder. A size of the all-silicon ITH raw powder is mainly distributed between 1 μm to 3 μm .

[0032] Low temperature nitrogen adsorption characterization (tested at 77 K using Micromeritics ASAP 2020 specific surface area and pore size distribution tester) shows that the molecular sieve is mainly formed by micropores in a low pressure area and stacked pores in a high pressure area, with a BET of 407 m^2/g , HK median pore width of 0.52 nm, t-plot surface area of 50 m^2/g , and a micropore volume of 0.17 cm^3/g .

2) Adding Binder for Granulation

[0033] The calcined all-silicon ITH raw powder, water, and a binder (acrylate latex A, solid content 50%) were mixed into a slurry at a mass ratio of 48:50:12, and then spray-dried using a nozzle with a 400 μm orifice diameter (tower top temperature of 180°C, tower top temperature of 140°C, spray pressure of 0.3 MPa) for granulation to obtain all-silicon ITH granules. Granules with a diameter of 270 μm to 330 μm were screened out and recorded as a sample 1 (average diameter 300 μm), and subjected to the following test.

3) Test Acoustic Performance:

[0034] A commercially available 1115-type loudspeaker was used. A volume of a rear cavity in tooling was 0.4 cubic centimeters (0.4 cc for short), and 100% canned. Specific data is shown in Table 1.

[0035] Acoustic performance is as shown in FIG. 2. After adding the all-silicon ITH molecular sieve (sample 1) to the rear cavity of the loudspeaker, the sound pressure value in the low-frequency band is significantly improved, and a resonant frequency also moves significantly to the low-frequency band.

[0036] Nitrogen adsorption and desorption at room temperature of the all-silicon ITH molecular sieve raw powder is as shown in FIG. 1. When tested at room temperature (25°C) (using Micromeritics ASAP 2020 specific surface area and pore

size distribution tester), an ITH adsorption amount is 15% to 20% higher than that of the existing Comparative Example 1, and the acoustic performance is approximately 10% to 15% higher than that of Comparative Example 1, which is basically corresponding to the nitrogen adsorption at room temperature.

Embodiment 2

[0037] In this embodiment, a boron-containing ITH molecular sieve (B-containing ITQ-13, with a Si/B ratio of 500) was prepared and applied to a loudspeaker to test acoustic performance of the loudspeaker, which includes the following steps.

1) Preparing Boron-containing ITH Molecular Sieve (B-containing ITQ-13, with Si/B Ratio of 500):

[0038] Based on Embodiment 1, boric acid was added as a boron source, and a specific ratio was 1 SiO₂:0.002 boric acid:0.5 hexamethonium hydroxide:0.5 HF:7 H₂O. A hydrothermal reaction temperature was 160°C, a reaction time was 120 h, and other conditions were the same as those in Embodiment 1, so as to obtain a boron-containing ITH molecular sieve raw powder.

[0039] Low temperature nitrogen adsorption characterization (tested at 77 K using Micromeritics ASAP 2020 specific surface area and pore size distribution tester) shows that the molecular sieve is mainly formed by micropores in a low pressure area and stacked pores in a high pressure area, with a BET of 378 m²/g, HK median pore width of 0.51 nm, t-plot surface area of 60 m²/g, and a micropore volume of 0.15 cm³/g.

2) Adding Binder for Granulation

[0040] The calcined boron-containing ITH raw powder, water, and a binder (acrylate latex A, solid content 50%) were mixed into a slurry at a mass ratio of 48:50:12, and then spray-dried with a 400 μm nozzle (tower top temperature of 180°C, tower top temperature of 140°C, spray pressure of 0.3 MPa) for granulation to obtain boron-containing ITH granules. Granules with a diameter of 270 μm to 330 μm were screened out and recorded as a sample 2 (average diameter of 300 μm), and subjected to the following test.

3) Test Acoustic Performance:

[0041] A commercially available 1115-type loudspeaker was used. A volume of a rear cavity in tooling was 0.4 cubic centimeters (0.4 cc for short), and 100% canned. Specific data is shown in Table 1.

Embodiment 3

[0042] In this embodiment, an aluminum-containing ITH molecular sieve (Al-containing ITQ-13, with a Si/Al ratio of 500) was prepared and applied to a loudspeaker to test acoustic performance of the loudspeaker, which includes the following steps.

1) Preparing Aluminum-containing ITH Molecular Sieve (Al-containing ITQ-13, with Si/Al Ratio of 500):

[0043] Based on Embodiment 1, sodium aluminate was added as an aluminum source, and a specific ratio was 1 SiO₂:0.002 sodium aluminate:0.5 hexamethonium hydroxide:0.5 HF:7 H₂O. A hydrothermal reaction temperature was 160°C, a reaction time was 120 h, and other conditions were the same as those in Embodiment 1, so as to obtain an aluminum-containing ITH molecular sieve raw powder.

[0044] Low temperature nitrogen adsorption characterization is as shown in FIG. 3, and the low temperature nitrogen adsorption characterization (tested at 77 K using Micromeritics ASAP 2020 specific surface area and pore size distribution tester) in FIG. 3 shows that the molecular sieve is mainly formed by micropores in a low pressure area and stacked pores in a high pressure area, with a BET of 417 m²/g, HK median pore width of 0.50 nm, t-plot surface area of 102 m²/g, and a micropore volume of 0.16 cm³/g.

2) Adding Binder for Granulation

[0045] The calcined aluminum-containing ITH raw powder, water, and a binder (acrylate latex A, solid content 50%) were mixed into a slurry at a ratio of 48:50:12, and then spray-dried with a 400 μm nozzle (tower top temperature of 180°C, tower top temperature of 140°C, spray pressure of 0.3 MPa) for granulation to obtain aluminum-containing ITH granules. Granules with a diameter of 270 μm to 330 μm were screened out and recorded as a sample 3 (average diameter of 300 μm), and subjected to the following test.

4) Testing Acoustic Performance:

[0046] A commercially available 1115-type loudspeaker was used. A volume of a tooling rear cavity was 0.4 cubic centimeters (0.4 cc for short), and 100% canned. Specific data is shown in Table 1.

Embodiment 4

[0047] In this embodiment, an aluminum-containing ITH molecular sieve (Al-containing ITQ-13, with a Si/Al ratio of 200) was prepared and applied to a loudspeaker to test acoustic performance of the loudspeaker, which includes the following steps.

1) Preparing Aluminum-containing ITH Molecular Sieve (Al-containing ITQ-13, with Si/Al Ratio of 200):

[0048] Based on Embodiment 1, sodium aluminate was added as an aluminum source, and a specific ratio was 1 SiO_2 :0.005 sodium aluminate:0.5 hexamethonium hydroxide:0.5 HF:7 H_2O . A hydrothermal reaction temperature was 160°C, a reaction time was 120 h, and other conditions were the same as those in Embodiment 1, so as to obtain an aluminum-containing ITH molecular sieve raw powder.

[0049] Low temperature nitrogen adsorption characterization (tested at 77 K using Micromeritics ASAP 2020 specific surface area and pore size distribution tester) shows that the molecular sieve is mainly formed by micropores in a low pressure area and stacked pores in a high pressure area, with a BET of 383 m^2/g , HK median pore width of 0.50 nm, t-plot surface area of 87 m^2/g , and a micropore volume of 0.13 cm^3/g .

2) Adding Binder for Granulation

[0050] The calcined aluminum-containing ITH raw powder, water, and a binder (acrylate latex A, solid content 50%) were mixed into a slurry at a ratio of 48:50:12, and then spray-dried with a 400 μm nozzle (tower top temperature of 180°C, tower top temperature of 140°C, spray pressure of 0.3 MPa) for granulation to obtain aluminum-containing ITH granules. Granules with a diameter of 270 μm to 330 μm were screened out and recorded as a sample 4 (average diameter of 300 μm), and subjected to the following test.

3) Testing Acoustic Performance:

[0051] A commercially available 1115-type loudspeaker was used. A volume of a tooling rear cavity was 0.4 cubic centimeters (0.4 cc for short), and 100% canned. Specific data is shown in Table 1.

Embodiment 5

[0052] The amount of boric acid was adjusted on the basis of Embodiment 2 to prepare a boron-containing ITH molecular sieve with a Si/B ratio of 100, which was then granulated to form a granule sample 5, and acoustic performance of granule sample 5 is shown in Table 1.

Embodiment 6

[0053] The amount of boric acid was adjusted on the basis of Embodiment 2 to prepare a boron-containing ITH molecular sieve with a Si/B ratio of 250, which was then granulated to form a granule sample 6, and acoustic performance of granule sample 6 is shown in Table 1.

Embodiment 7

[0054] The ITH molecular sieve obtained in Embodiment 3 was ion-exchanged with a 2 M ammonium nitrate solvent at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the ion-exchange, the reactant was washed with water 4 times, dried, and calcined to obtain a hydrogen-type ITH molecular sieve.

[0055] The hydrogen-type ITH molecular sieve was formed and granulated to obtain a granule sample 7 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 7 is shown in Table 1.

Embodiment 8

[0056] The ITH molecular sieve obtained in Embodiment 3 was ion-exchanged with a lithium salt to obtain a lithium-form

ITH molecular sieve. The ion-exchange was performed using a 2 M lithium chloride solvent at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the ion-exchange, the product was washed with water 4 times, dried, and calcined to obtain the lithium-form ITH molecular sieve.

[0057] The lithium-form ITH molecular sieve was formed and granulated to obtain a granule sample 8 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 8 is shown in Table 1.

Embodiment 9

[0058] The ITH molecular sieve obtained in Embodiment 3 was ion-exchanged with a sodium salt to obtain a sodium-form ITH molecular sieve. The ion-exchange was performed using a 2 M sodium chloride solvent at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the ion-exchange, the reactant was washed with water 4 times, dried, and calcined to obtain the sodium-form ITH molecular sieve.

[0059] The sodium-form ITH molecular sieve was formed and granulated to obtain a granule sample 9 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 9 is shown in Table 1.

Embodiment 10

[0060] The ITH molecular sieve obtained in Embodiment 3 was ion-exchanged with a potassium salt to obtain a potassium-form ITH molecular sieve. The ion-exchange was performed using a 2 M potassium chloride solvent at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the ion-exchange, the product was washed with water 4 times, dried, and calcined to obtain the potassium-type ITH molecular sieve.

[0061] The potassium-type ITH molecular sieve was formed and granulated to obtain a granule sample 10 according to the formation conditions in Embodiment 1, and the acoustic performance thereof is shown in Table 1.

Embodiment 11

[0062] The ITH molecular sieve obtained in Embodiment 3 was ion-exchanged with a potassium salt and a sodium salt to obtain a mixed potassium/sodium-form ITH molecular sieve. The ion-exchange was performed using a solution containing 1 M potassium chloride and 1 M sodium chloride, at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the ion-exchange, the product was washed with water 4 times, dried, and calcined to obtain the potassium/sodium-form ITH molecular sieve.

[0063] The potassium/sodium-form ITH molecular sieve was formed and granulated to obtain a granule sample 11 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 11 is shown in Table 1.

Embodiment 12

[0064] The ITH molecular sieve obtained in Embodiment 2 was ion-exchanged with a magnesium salt to obtain a magnesium-form ITH molecular sieve. The ion-exchange was performed using a 2 M magnesium chloride solvent at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the exchange, the product was washed with water 4 times, dried, and calcined to obtain the magnesium-form ITH molecular sieve.

[0065] The magnesium-form ITH molecular sieve was formed and granulated to obtain a granule sample 12 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 12 is shown in Table 1.

Embodiment 13

[0066] The ITH molecular sieve obtained in Embodiment 2 was exchanged with a magnesium salt and a sodium salt to obtain a mixed magnesium/sodium-type ITH molecular sieve. The exchange was performed using a solution containing 1 M magnesium chloride and 1 M sodium chloride, at 80°C for 6 h, with a ratio of the molecular sieve to the solution of 1:10. After the exchange, the reactant was washed with water 4 times, dried, and calcined to obtain the magnesium/sodium-type ITH molecular sieve.

[0067] The magnesium/sodium-type ITH molecular sieve was formed and granulated to obtain a granule sample 13 according to the formation conditions in Embodiment 1, and the acoustic performance of granule sample 13 is shown in Table 1.

Comparative Example 1

[0068] A loudspeaker of an Apple X-generation mobile phone sold on the market was disassembled, and granules of a

comparative sample 1 in a rear cavity were taken out for comparative testing. Acoustic performance of comparative sample 1 is shown in Table 1, and nitrogen adsorption under room temperature of comparative sample 1 is shown in FIG. 1 (the sample was calcined to remove organic glue before the test).

[0069] The acoustic performance thereof is shown in Table 1.

Table 1 Resonance Frequency F0 and Q Value Before and After Adding Molecular Sieve to Rear cavity of Loudspeaker

	No molecular sieve added to rear cavity of loudspeaker	After adding 0.4 cc molecular sieve to rear cavity of loudspeaker	Reduction value
	F0/Hz	FO/Hz	$\Delta F0/Hz$
Sample 1	898.5	746.2	152.3
Sample 2	897.6	741.6	156.0
Sample 3	899.2	742.2	157.0
Sample 4	899.0	762.0	137.0
Sample 5	899.2	762.2	137.0
Sample 6	899.1	749.1	150.0
Sample 7	899.4	751.1	148.3
Sample 8	899.6	749.1	150.5
Sample 9	899.5	744.1	155.4
Sample 10	898.5	754.1	144.4
Sample 11	899.7	749.1	150.6
Sample 12	899.8	748.1	151.7
Sample 13	899.2	749.1	150.1
Comparative sample 1	899.5	764.1	135.4

[0070] It can be seen from Table 1 that the overall performance of the ITH molecular sieve is improved by 15 Hz to 20 Hz as compared with the comparative sample 1, and the low-frequency effect is significantly enhanced, which indicates that the ITH molecular sieve of the present disclosure has significant technical progress in acoustic performance.

[0071] Obviously, the above-described Embodiments of the present disclosure are merely embodiments for clearly describing the present disclosure, and are not intended to limit embodiments of the present disclosure. For those having ordinary skills in the art, other different forms of changes or modifications can be made based on the above description. An exhaustive list of all embodiments is neither necessary nor possible, and obvious changes or modifications derived from the technical solution of the present disclosure are still within the protection scope of the present disclosure.

Claims

1. A loudspeaker improved by an ITH molecular sieve, wherein

a rear cavity of the loudspeaker is filled with the ITH molecular sieve, the ITH molecular sieve comprises a framework and extra-framework cations, the framework comprises silicon dioxide and an oxide of a non-silicon element M, and a Si/M molar ratio is at least 80 or more, and the ITH molecular sieve has uniform micropores with a micropore size of 0.4 Å to 0.55 Å and a micropore volume of 0.10 cm³/g to 0.25 cm³/g.

2. The loudspeaker according to claim 1, wherein the micropore volume is 0.15 cm³/g to 0.25 cm³/g.

3. The loudspeaker according to claim 1, wherein the non-silicon element M is selected from at least one selected from the group consisting of Al, Fe, B, Ge, Ga, Ti and Zr.

4. The loudspeaker according to claim 1, wherein the non-silicon element M is B or Al.

5. The loudspeaker according to claim 1, wherein

the extra-framework cations are selected from at least one selected from the group consisting of H ions, alkali metal ions, or alkaline earth metal ions, and a content of the extra-framework cations is 0.05 wt.% to 1.5 wt.%.

6. The loudspeaker according to claim 1, wherein a grain size of the ITH molecular sieve is greater than 10 nanometers.

7. The loudspeaker according to claim 6, wherein the grain size of the ITH molecular sieve is less than 10 micrometers.

8. The loudspeaker according to any one of claims 1 to 7, wherein in the rear cavity, a binder is added to the ITH molecular sieve to form a specific shape.

9. The loudspeaker according to claim 8, wherein the specific shape comprises a granule-like shape, a sheet-like shape, and a block-like shape.

10. The loudspeaker according to claim 9, wherein the formation in granule-like shape has a size of 80 μm to 2000 μm .

11. The loudspeaker according to claim 9, wherein the formation in sheet-like shape has a thickness of 100 μm to 1000 μm , and a length and a width of 3 mm to 100 mm.

12. The loudspeaker according to claim 9, wherein the formation in block-like shape has a thickness of 1 mm to 20 mm, and a length and a width of 3 mm to 100 mm.

13. The loudspeaker according to any one of claims 1 to 7, wherein the framework of the ITH molecular sieve excludes the oxide of the non-silicon element M.

14. An electronic device comprising the speaker according to any one of claims 1 to 13.

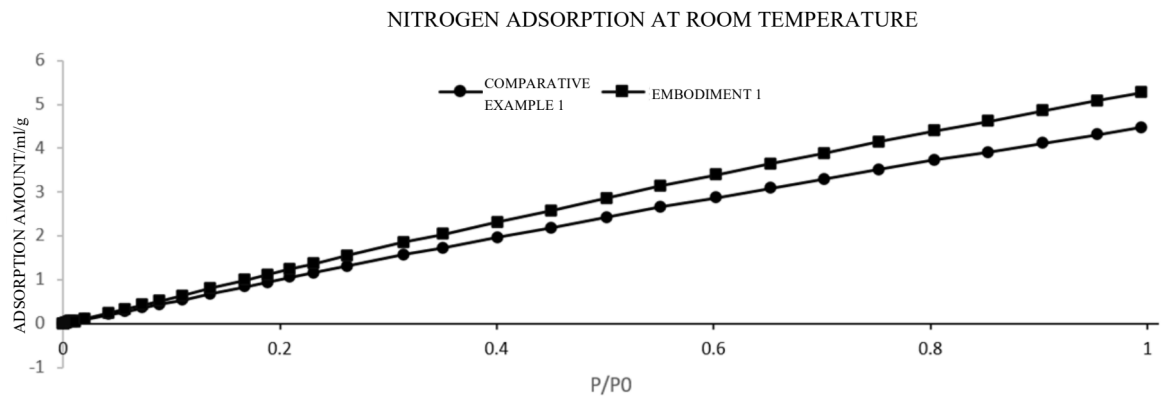


FIG. 1

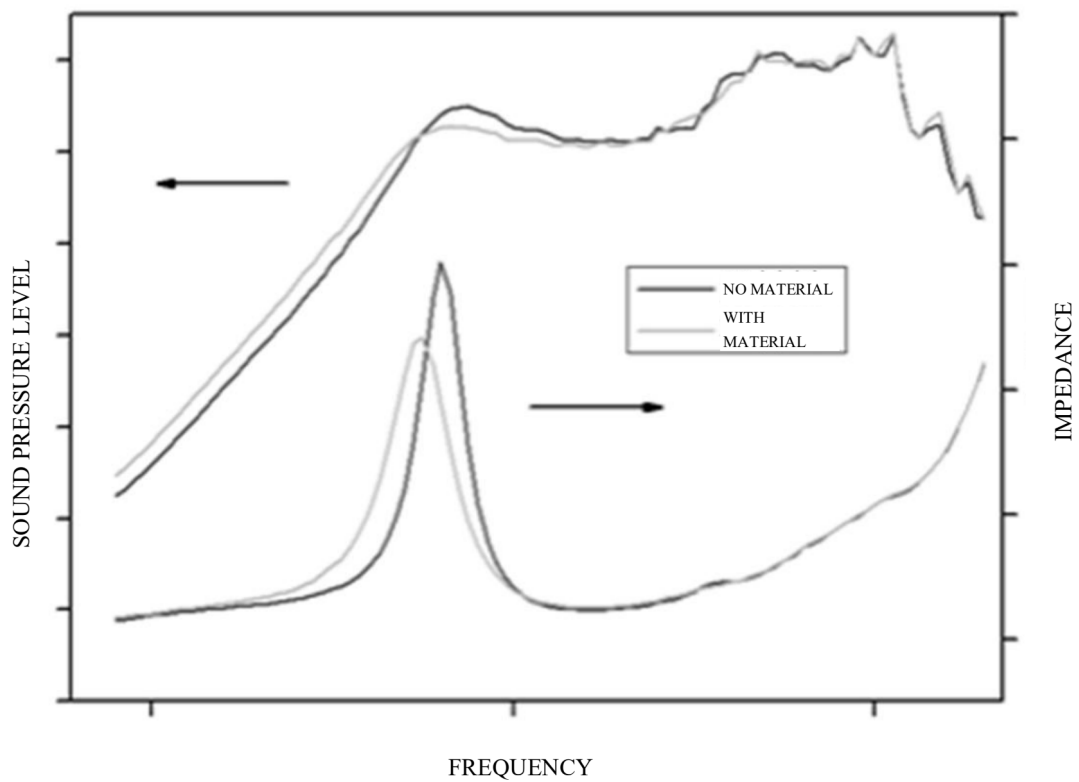


FIG. 2

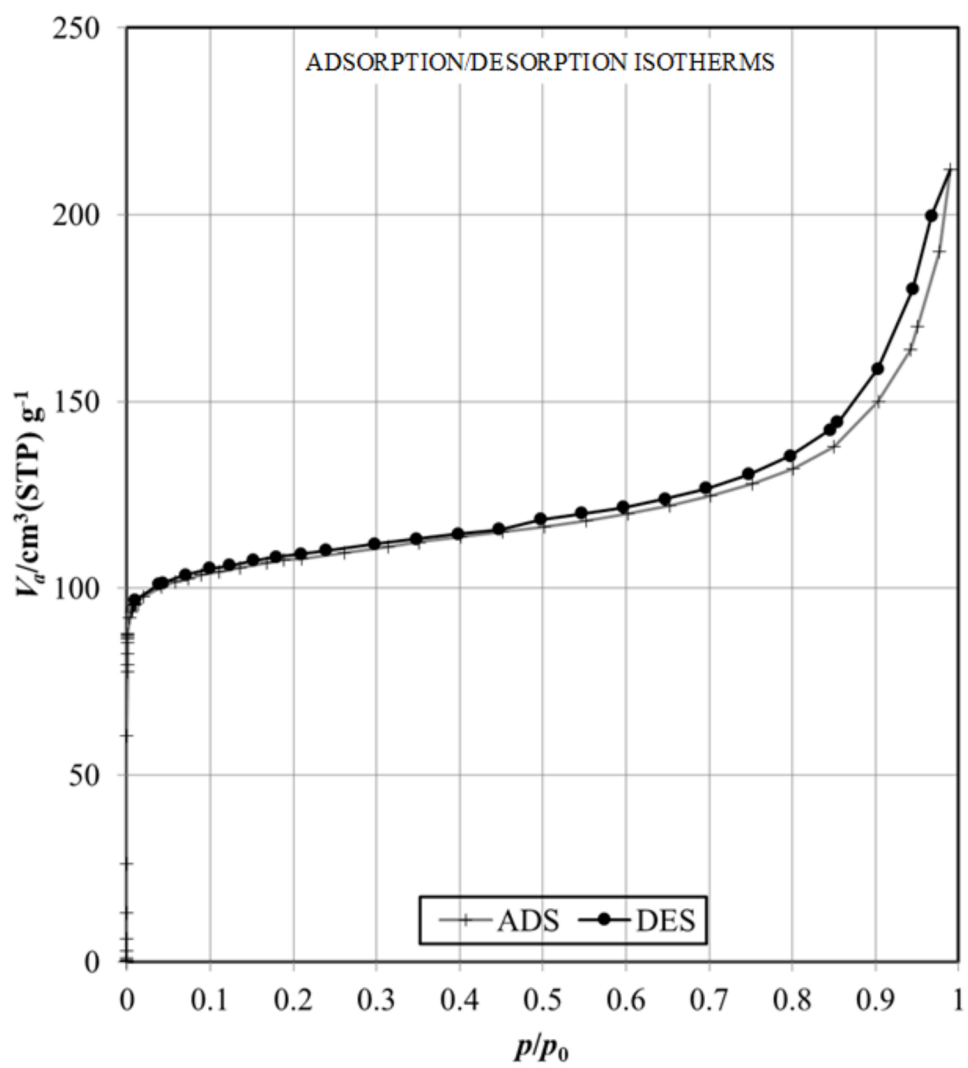


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/081868

A. CLASSIFICATION OF SUBJECT MATTER

H04R9/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, DWPI, ENTXTC, ENTXT: 扬声器, 后声腔, 后腔, 分子筛, 微孔, 吸附, 尺寸, 孔径, speaker, loudspeaker, rear acoustic cavity, rear cavity, ITH, ITQ-13, molecular sieve, microporous, adsorb+, dimension, pore size

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 116320927 A (ZHENJIANG BEST NEW MATERIAL CO., LTD.) 23 June 2023 (2023-06-23) claims 1-13	1-14
Y	CN 109133093 A (AAC TECHNOLOGIES (NANJING) INC.) 04 January 2019 (2019-01-04) description, paragraphs [0041]-[0121], and figures 1-8	1-14
Y	CN 106792387 A (AAC TECHNOLOGIES (NANJING) INC.) 31 May 2017 (2017-05-31) description, paragraphs [0035]-[0049], and figures 1-8	1-14
Y	CN 108275696 A (AAC TECHNOLOGIES PTE. LTD.) 13 July 2018 (2018-07-13) description, paragraphs [0022]-[0042], and figures 1-5	1-14
Y	CN 106542546 A (CHINA UNIVERSITY OF PETROLEUM, BEIJING) 29 March 2017 (2017-03-29) description, paragraphs [0004]-[0072], and figure 5	1-14
A	CN 108996515 A (AAC TECHNOLOGIES (NANJING) INC.) 14 December 2018 (2018-12-14) entire document	1-14

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search	Date of mailing of the international search report
18 April 2024	23 April 2024
Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/081868

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 109511064 A (AAC TECHNOLOGIES (NANJING) INC.) 22 March 2019 (2019-03-22) entire document	1-14
A	CN 109801616 A (AAC TECHNOLOGIES (NANJING) INC.) 24 May 2019 (2019-05-24) entire document	1-14
A	CN 113184876 A (SHANDONG SINOCERA FUNCTIONAL MATERIAL CO., LTD.) 30 July 2021 (2021-07-30) entire document	1-14
A	CN 114229862 A (SHENZHEN SUNWAY COMMUNICATION CO., LTD.) 25 March 2022 (2022-03-25) entire document	1-14
A	US 2007087934 A1 (R M MARTENS LUC; P B KREMER SEBASTIEN) 19 April 2007 (2007-04-19) entire document	1-14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/081868

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	116320927	A	23 June 2023	None			
CN	109133093	A	04 January 2019	US	2020037066	A1	30 January 2020
CN	106792387	A	31 May 2017	US	2018167721	A1	14 June 2018
				US	10271130	B2	23 April 2019
CN	108275696	A	13 July 2018	None			
CN	106542546	A	29 March 2017	None			
CN	108996515	A	14 December 2018	US	2020037062	A1	30 January 2020
				US	10939195	B2	02 March 2021
CN	109511064	A	22 March 2019	None			
CN	109801616	A	24 May 2019	None			
CN	113184876	A	30 July 2021	None			
CN	114229862	A	25 March 2022	None			
US	2007087934	A1	19 April 2007	US	7678955	B2	16 March 2010

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202310250461 [0001]
- CN 101416528 A [0005]
- CN 103477655 A [0005]
- CN 105013436 A [0005]